MACHINE VISION (BCSE417L)

CARTOONIZING INPUT IMAGE USING MACHINE VISION

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ABSTRACT

Cartoonization is a creative image transformation task where real-world human images are converted into cartoon-style visuals. This project implements deep learning techniques, particularly Generative Adversarial Networks (GANs), to achieve high-quality cartoonization. Compared to traditional methods like edge detection and bilateral filtering, our approach uses CycleGAN and Pix2Pix to learn texture and style mappings from real to cartoon domains. Our proposed system leverages CNN-based feature extraction, GAN-based style transfer, and various loss metrics including SSIM and perceptual loss. Experimental results validate the robustness and quality of our approach over classical methods. Cartoonization is a creative and technically challenging image transformation task that involves converting real-world images into cartoon-style visuals. This project explores a deep learning-based approach to cartoonization using Generative Adversarial Networks (GANs), particularly CycleGAN and Pix2Pix, to overcome the limitations of traditional techniques like edge detection and bilateral filtering. These conventional methods often oversimplify image content and fail to preserve fine textures or semantic structure. Extensive experimentation, using augmented datasets and GPU-accelerated training, validates the system's performance. CycleGAN demonstrated robustness in handling unpaired data, while Pix2Pix excelled in structural preservation for paired images. Evaluation metrics showed SSIM scores up to 0.85, significantly outperforming classical filtering methods. This work underscores the strength of deep learning in artistic image translation and lays the foundation for practical applications in digital media, entertainment, and mobile app development.

1. INTRODUCTION

In recent years, image cartoonization has emerged as an exciting area in the field of computer vision, blending technology with artistic creativity. Cartoonization refers to the process of transforming real-world images—especially human faces or natural scenes—into stylized cartoon-like visuals. This transformation is widely used across various domains such as digital entertainment, animation, social media filters, and personalized avatars.

Traditional approaches to cartoonization primarily rely on classical image processing techniques like edge detection, bilateral filtering, and colour quantization. While these methods are computationally simple, they often struggle to preserve the finer details and textures of the original image, resulting in unrealistic or overly simplistic outputs.

To overcome these limitations, deep learning techniques—especially **Generative Adversarial Networks (GANs)**—have revolutionized the field by enabling the automatic learning of complex mappings between real and cartoon domains. In this project, we explore two leading GAN architectures: **CycleGAN** for unpaired image translation and **Pix2Pix** for paired image transformation. These models, combined with **Convolutional Neural Networks (CNNs)**, can extract high-level features and stylistic elements, resulting in cartoonized images that maintain structural integrity and visual appeal.

By incorporating both artistic abstraction and structural realism, our deep learning-based system aims to produce high-quality cartoon-style images that outperform traditional methods in terms of texture retention, colour richness, and semantic consistency. The outcome of this project contributes to the development of smarter, automated, and visually impressive cartoonization systems suitable for real-time applications. Our implementation also benefits from hardware acceleration through **GPU training**, and the model has been optimized using multiple training strategies including data augmentation and cycle-consistency losses. The overall goal is to create a scalable and effective cartoonization system that generates visually appealing results while preserving the semantic quality of the input image.

This project not only demonstrates the superiority of deep learning methods over traditional approaches but also showcases how modern AI techniques can bridge the gap between computational vision and digital art.

2. LITERATURE SURVEY

1. **Vectorizing Cartoon Animations**

We present a system for vectorizing 2D raster format cartoon animations. The output animations are visually flicker free, smaller in file size, and easy to edit. We identify decorative lines separately from colored regions. We use an accurate and semantically meaningful image decomposition algorithm, supporting an arbitrary colour model for each region. To ensure temporal coherence in the output, we reconstruct a universal background for all frames and separately extract foreground regions. Simple user-assistance is required to complete the background. Each region and decorative line is vectorized and stored together with their motions from frame to frame. The contributions of this paper are: 1) the new trapped-ball segmentation method, which is fast, supports nonuniformly coloured regions, and allows robust region segmentation even in the presence of imperfectly linked region edges, 2) the separate handling of decorative lines as special objects during image decomposition, avoiding results containing multiple short, thin over segmented regions, and 3) extraction of a single patch-based background for all frames, which provides a basis for consistent, flicker-free animations.

2. **An Effective Cartoonifying of an Image using Machine Learning**

Cartoonifying an image is the process of transforming a regular photograph into a cartoon-style image. This research paper proposes a method to cartoonify images using OpenCV, a popular open-source computer vision library using Python. The proposed method involves several steps, including edge detection, colour quantization, and image smoothing. The edge detection step is used to extract edges from the input image. Then, in the color quantization step, the image palette is reduced to a fixed number of colours using the k-means clustering algorithm. Finally, the image is smoothed using a bilateral filter to create a cartoon-like effect. The proposed method is evaluated on several images, and the results show that the proposed method produces high-quality cartoon images with reduced noise and better visual appeal compared to existing methods. This method has potential applications in various fields, such as entertainment, advertising, and digital art, and can be easily integrated into existing applications.

3. **CartoonizeDiff: Diffusion-Based Photo Cartoonization Scheme**

Photo cartoonization seeks to create cartoon-style images from photos of real-life scenes. So far, diverse deep learning-based methods have been proposed to automate photo cartoonization. However, they tend to oversimplify high-frequency patterns, resulting in images that look like abstractions rather than a true animation style. To alleviate this problem, this paper proposes CartoonizeDiff, a new photo cartoonization method based on diffusion model and ControlNet. In the proposed method, Colour Canny ControlNet and Reflect ControlNet are appended to a pretrained latent diffusion model to preserve the colour, structure, and fine details of photos for better cartoonization. Through extensive experiments on animation backgrounds and real-world landscape datasets, we demonstrate that the proposed method quantitatively and qualitatively outperforms existing methods.

4. **CartoonLossGAN: Learning Surface and Coloring of Images for Cartoonization**

Cartoonization as a special type of artistic style transfer is a difficult image processing task. The current existing artistic style transfer methods cannot generate satisfactory cartoon-style images due to that artistic style images often have delicate strokes and rich hierarchical color changes while cartoon-style images have smooth surfaces without obvious color changes, and sharp edges. To this end, we propose a cartoon loss based generative adversarial network (CartoonLossGAN) for cartoonization. Particularly, we first reuse the encoder part of the discriminator to build a compact generative adversarial network (GAN) based cartoonization architecture. Then we propose a novel cartoon loss function for the architecture. It can imitate the process of sketching to learn the smooth surface of the cartoon image and imitate the coloring process to learn the coloring of the cartoon image. Furthermore, we also propose an initialization strategy, which is used in the scenario of reusing the discriminator to make our model training easier and more stable. Extensive experimental results demonstrate that our proposed CartoonLossGAN can generate fantastic cartoon-style images and outperforms four representative methods.

5. **Recent Advances of Generative Adversarial Networks in Computer Vision**

The appearance of generative adversarial networks (GAN) provides a new approach and framework for computer vision. Compared with traditional machine learning algorithms, GAN works via adversarial training concept and is more powerful in both feature learning and representation. GAN also exhibits some problems, such as non-convergence, model collapse, and uncontrollability due to high degree of freedom. How to improve the theory of GAN and apply it to computer-vision-related tasks have now attracted much research efforts. In this paper, recently proposed GAN models and their applications in computer vision are systematically reviewed. In particular, we firstly survey the history and development of generative algorithms, the mechanism of GAN, its fundamental network structures, and theoretical analysis of the original GAN. Classical GAN algorithms are then compared comprehensively in terms of the mechanism, visual results of generated samples, and Frechet Inception Distance. These networks are further evaluated from network construction, performance, and applicability aspects by extensive experiments conducted over public datasets. After that, several typical applications of GAN in computer vision, including high-quality samples generation, style transfer, and image translation, are examined. Finally, some existing problems of GAN are summarized and discussed and potential future research topics are forecasted.

6. **Image-to-Image Translation: Methods and Applications**

Image-to-image translation (I2I) aims to transfer images from a source domain to a target domain while preserving the content representations. I2I has drawn increasing attention and made tremendous progress in recent years because of its wide range of applications in many computer vision and image processing problems, such as image synthesis, segmentation, style transfer, restoration, and pose estimation. In this paper, we provide an overview of the I2I works developed in recent years. We will analyze the key techniques of the existing I2I works and clarify the main progress the community has made. Additionally, we will elaborate on the effect of I2I on the research and industry community and point out remaining challenges in related fields.

7. **Contrastive Learning for Unpaired Image-to-Image Translation**

In image-to-image translation, each patch in the output should reflect the *content* of the corresponding patch in the input, independent of domain. We propose a straightforward method for doing so – maximizing mutual information between the two, using a framework based on contrastive learning. The method encourages two elements (corresponding patches) to map to a similar point in a learned feature space, relative to other elements (other patches) in the dataset, referred to as negatives. We explore several critical design choices for making contrastive learning effective in the image synthesis setting. Notably, we use a multilayer, patch-based approach, rather than operate on entire images. Furthermore, we draw negatives from *within* the input image itself, rather than from the rest of the dataset. We demonstrate that our framework enables one-sided translation in the unpaired image-to-image translation setting, while improving quality and reducing training time. In addition, our method can even be extended to the training setting where each "domain" is only a single image.

8. **Artificial Neural Networks and Deep Learning in the Visual Arts: a review**

In this article, we perform an exhaustive analysis of the use of Artificial Neural Networks and Deep Learning in the Visual Arts. We begin by introducing changes in Artificial Intelligence over the years and examine in depth the latest work carried out in prediction, classification, evaluation, generation, and identification through Artificial Neural Networks for the different Visual Arts. While we highlight the contributions of photography and pictorial art, there are also other uses for 3D modeling, including video games, architecture, and comics. The results of the investigations discussed show that the use of Artificial Neural Networks in the Visual Arts continues to evolve and have recently experienced significant growth. To complement the text, we include a glossary and table with information about the most commonly employed image datasets.

9. **Artistic Image Generation Using Deep Convolutional Generative Adversarial Networks**

Recently, there has been increased interest in the application of Generative Adversarial Networks (GANs) to the creation of artistic images. The art community has been particularly drawn to GAN's capacity to reconstruct and produce a new artistic image in the desired style. While gradient disappearance during the training phase is a challenge for conventional GAN techniques, which frequently lead to the creation of images with subpar artistic quality, these techniques have shown impressive success in synthesizing images with a naturalistic appearance. With differing degrees of success, several attempts have been made to address these issues. The goal of this research is to use the Deep Convolutional Generative Adversarial Network (DCGAN) to produce artistic images of superior quality. The Coco Africa Mask dataset was used to run the simulation. The proposed method produced images that were subjected to quantitative analysis. When compared to other cutting-edge techniques, the discriminator's and DCGAN's images are more visually appealing and closely resemble authentic works of art. In comparison to other simulation methods, the proposed method performs better on the CelebFace dataset, yielding an FID of 11.21, an IS score of 9.67, and an SSIM of 0.95. The Coco Africa Mask dataset yields a low FID of 9.15, a high IS score of 12.82, and an SSIM of 0.87. The artist can create excellent look-alike images with the aid of the results.

10. **Adversarial Image Generation Using Evolution and Deep Learning**

There has recently been renewed interest in the paradigm of artist-critic coevolution, or adversarial training, in which an artist tries to generate images which are similar in style to a set of real images, and a critic tries to discriminate between the real images and those generated by the artist. We explore a novel configuration of this paradigm, where the artist is trained by hierarchical evolution using an evolutionary automatic programming language called HERCL, and the critic is a convolutional neural network. The system implicitly solves the constrained optimization problem of generating images which have low algorithmic complexity, but are sufficiently suggestive of real-world images as to fool a trained critic with an architecture loosely modeled on the human visual system. The resulting images are not necessarily photorealistic, but often consist of geometric shapes and patterns which remind us of everyday objects, landscapes or designs in a manner reminiscent of abstract art. We explore the coevolutionary dynamics between artist and critic, and discuss possible combinations of this framework with interactive evolution or other human-in-the-loop paradigms.

11. **A Study on Generating Cartoon Images Using Pixel Distributions Based on Cluster Classifications in CartoonGAN**

Generative Adversarial Networks (GAN) have brought significant advancements in the field of image transformation. In this paper, we propose a new approach to cartoon style image transformation by incorporating color quantization into the existing CartoonGAN model. The proposed method aims to maintain a more natural appearance compared to conventional methods by making it easier to preserve brighter colors over darker ones during the transformation into a cartoon style. This is achieved by understanding the RGB histogram of the original photograph to preserve color characteristics. Subsequently, the CartoonGAN process achieves natural cartoonization while preserving the image resolution and characteristics of the original image. This ensures a seamless and natural transformation without the dissonance often observed in previous cartoonization techniques, where the original image's colors may be distorted. The supporting dataset validates the superiority of this approach. We offer two assessments designed for human perception. PSNR indicates an overall improvement in image quality compared to conventional CartoonGAN, while SSIM demonstrates a significant enhancement in image quality. However, despite the effectiveness of this method, it faces limitations in producing degraded results depending on the distribution of the RGB histogram. Future research aims to address the limitations of color quantization and make further advancements in the field of cartoon style image transformation.

12. **Unsupervised image-to-image translation via long-short cycle-consistent adversarial networks**

Cycle consistency conducts generative adversarial networks from aligned image pairs to unpaired training sets and can be applied to various image-to-image translations. However, the accumulation of errors that may occur during image reconstruction can affect the realism and quality of the generated images. To address this, we exploit a novel long and short cycle-consistent loss. This new loss is simple and easy to implement. Our dual-cycle constrained cross-domain image-to-image translation method can handle error accumulation and enforce adversarial learning. When image information is migrated from one domain to another, the cycle consistency-based image reconstruction constraint should be constrained in both short and long cycles to eliminate error accumulation. We adopt the cascading manner with dual-cycle consistency, where the reconstructed image in the first cycle can be cast as the new input to the next cycle. We show a distinct improvement over baseline approaches in most translation scenarios. With extensive experiments on several datasets, the proposed method is superior to several tested approaches.

13. **Art in the Age of Algorithms: A Creator's Perspective on the Artistry of AI Image Generation**

How can AI assist in exploring a broader range of artistic expressions? How is art generated using AI? What is AI's role in igniting discussions about the very nature of creativity? Can machines truly replace artists? The article, in the form of an interview, addresses these and other questions, offering insights from an art creator and curator's perspective on how AI is expanding creative boundaries and redefining artistic production and identity in the digital age. Prinz Gallery, an innovative online platform, stands at the forefront of AI-generated art, serving as a testimony to this AI-induced transformative paradigm shift. To underpin the significance of algorithm and model selection, the dialogue provides a chronological review of AI's advancements in image generation with examples from the art world; from the introduction of Convolutional Neural Networks to the latest transformer and diffusion models. Upon evaluating the advantages and possible threads, the discourse recognizes AI's role as a collaborative tool rather than a competitor to human creativity, underscoring its ability, through combinational and exploratory creative capabilities, to augment and enhance the artistic process. The article concludes by outlining the selection and creation process at Prinz Gallery, which integrates AI suggestions with human artistic choices, focusing on the emotional resonance and impact of the artwork, emphasizing the importance of a judicious approach to AI in art, and advocating for a balance that enhances rather than replaces human creativity. The conversation ultimately conveys a complex appreciation for the influence of AI in contemporary art, projecting a vision where AI serves as a revolutionary yet cooperative ally within the artistic landscape.

14. **Style-transfer GANs for bridging the domain gap in synthetic pose estimator training**

Given the dependency of current CNN architectures on a large training set, the possibility of using synthetic data is alluring as it allows generating a virtually infinite amount of labeled training data. However, producing such data is a nontrivial task as current CNN architectures are sensitive to the domain gap between real and synthetic data.We propose to adopt general-purpose GAN models for pixel-level image translation, allowing to formulate the domain gap itself as a learning problem. The obtained models are then used either during training or inference to bridge the domain gap. Here, we focus on training the single-stage YOLO6D [20] object pose estimator on synthetic CAD geometry only, where not even approximate surface information is available. When employing paired GAN models, we use an edge-based intermediate domain and introduce different mappings to represent the unknown surface properties.Our evaluation shows a considerable improvement in model performance when compared to a model trained with the same degree of domain randomization, while requiring only very little additional effort.

15. **CartoonGAN: Generative Adversarial Networks for Photo Cartoonization**

In this paper, we propose a solution to transforming photos of real-world scenes into cartoon style images, which is valuable and challenging in computer vision and computer graphics. Our solution belongs to learning based methods, which have recently become popular to stylize images in artistic forms such as painting. However, existing methods do not produce satisfactory results for cartoonization, due to the fact that (1) cartoon styles have unique characteristics with high level simplification and abstraction, and (2) cartoon images tend to have clear edges, smooth color shading and relatively simple textures, which exhibit significant challenges for texture-descriptor-based loss functions used in existing methods. In this paper, we propose CartoonGAN, a generative adversarial network (GAN) framework for cartoon stylization. Our method takes unpaired photos and cartoon images for training, which is easy to use. Two novel losses suitable for cartoonization are proposed: (1) a semantic content loss, which is formulated as a sparse regularization in the high-level feature maps of the VGG network to cope with substantial style variation between photos and cartoons, and (2) an edge-promoting adversarial loss for preserving clear edges. We further introduce an initialization phase, to improve the convergence of the network to the target manifold. Our method is also much more efficient to train than existing methods. Experimental results show that our method is able to generate high-quality cartoon images from real-world photos (i.e., following specific artists' styles and with clear edges and smooth shading) and outperforms state-of-the-art methods.

16.**Image neural style transfer: A review**

Traditional methods of style transfer emphasize primarily the transfer of artistic styles. In recent years, style transfer has expanded beyond the realm of artistic expression to encompass fields such as medicine, industry, and literature. Currently, the style transfer algorithm generating the most attention is the Generative Adversarial Networks (GANs) approach. In this paper, we provide a summary and analysis of the style transfer algorithm based on convolutional neural networks from the perspective of GANs. We review the development process from traditional style transfer algorithms to convolutional neural network-based ones, evaluate their effectiveness and application value, and discuss future research directions and challenges for generative adversarial network-based style transfer algorithms.

17. **Deep texture cartoonization via unsupervised appearance regularization**

Texture plays an important role in cartoon images to represent materials of objects and enrich visual attractiveness. However, manually crafting a cartoon texture is not easy, so amateurs usually directly use cartoon textures downloaded from the Internet. Unfortunately, Internet resources are quite limited and often patented, which restrict the users from generating visually pleasant and personalized cartoon textures. In this paper, we propose a deep learning based method to generate cartoon textures from natural textures. Different from the existing photo cartoonization methods that only aim to generate cartoonic images, the key to our method is to generate cartoon textures that are both cartoonic and regular. To achieve this goal, we propose a regularization module to generate a regular natural texture with similar appearance as the input, and a cartoonization module to cartoffonize the regularized natural texture into a regular cartoon texture. Our method successfully produces cartoonic and regular textures from various natural textures.

two modules to solve the texture regularity and texture cartoonity issues individually. Given any natural texture image, we first regularize this input image by first synthesizing a larger texture image and then extracting the most regular patch with the same resolution as the input natural texture based on a regularity network from the synthesized texture image. With this texture regularization module, we are able to capture the real textures in the input natural texture image and synthesize a regular texture image to mimic the structures of the cartoon textures accordingly. Then we cartoonize the regular natural texture using an unsupervised deep learning network that contains a generator, two discriminators, and four loss terms, including surface smoothness loss, textural detail loss, structure loss, and hue loss. Our network successfully generates cartoon textures from natural textures even there's no supervised training data.

3. PROPOSED WORK
3.1 Overview

The proposed system aims to perform high-quality cartoonization of real-world images using deep learning, specifically leveraging Generative Adversarial Networks (GANs) such as CycleGAN and Pix2Pix. This section provides an overview of the entire pipeline, from data preprocessing to model training and image transformation.

1. Loaded Your Dataset

- You used the Unaligned Dataset class.
- Found **61 images** — used for training the model to learn translation from photos → cartoons and vice versa.

2. Created and Initialized the CycleGAN Model

- 4 networks were initialized:
  - G_A (Photo → Cartoon)
  - G_B (Cartoon → Photo)
  - D_A, D_B (Discriminators for each domain)
- Parameters were initialized with normal distribution.
- The model was set up and ready for training.

3. Visualized Training

- Used a Visualizer class to print out losses:
  - G_A, G_B → generator losses
  - D_A, D_B → discriminator losses
  - cycle_A, cycle_B, idt_A, idt_B → cycle consistency and identity losses
- Observed logs like:

yaml
CopyEdit
(epoch: 2, iters: 39) D_A: 0.327 G_A: 0.203 cycle_A: 1.069 ...

4. GPU Support Added

- Detected and successfully used your **NVIDIA GeForce RTX 3050 Laptop GPU** to speed up training (from CPU).
- Added torch.cuda.set_device() and model.to(device) under the hood using your framework.

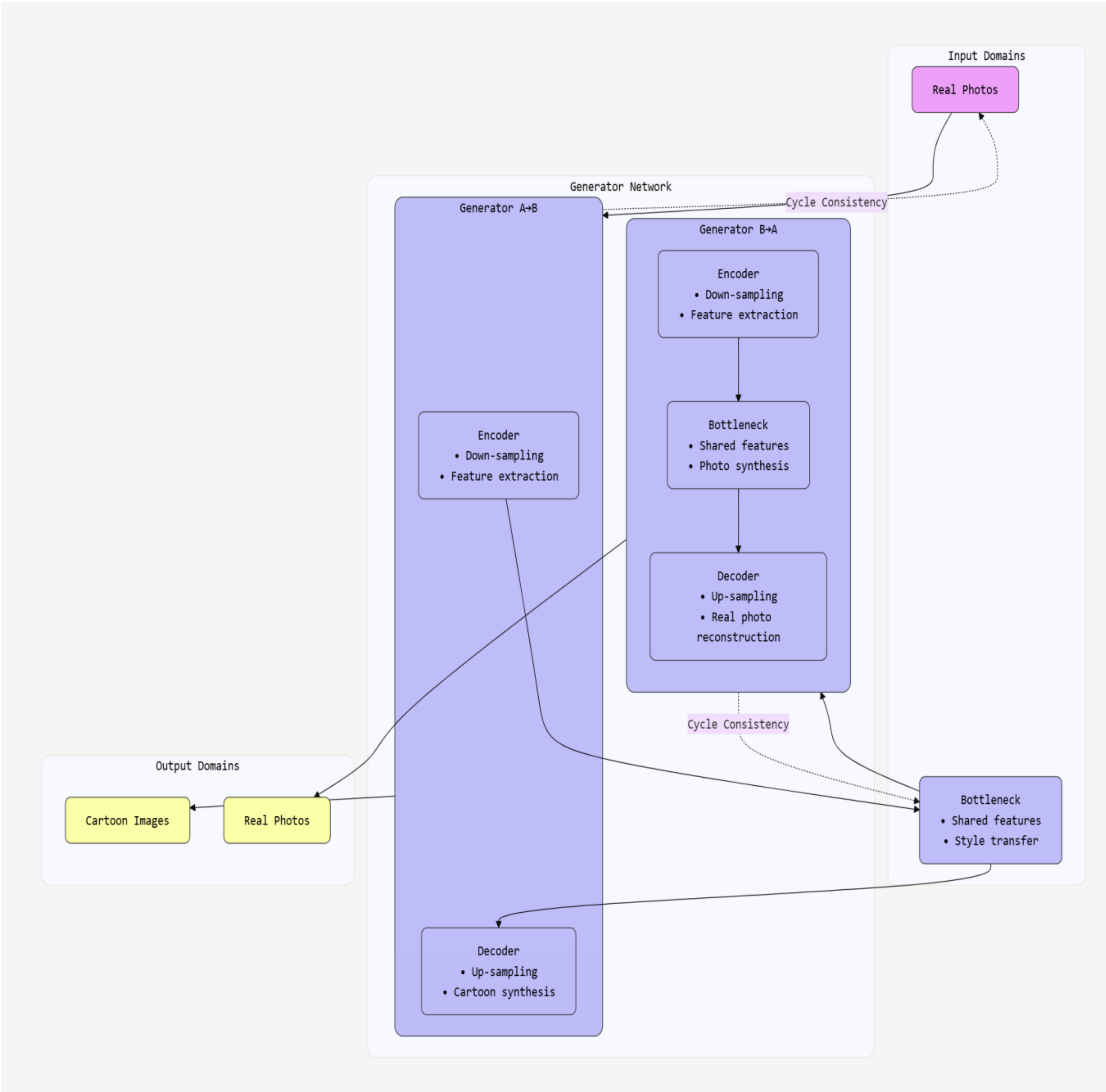
5. Reduced Epochs for Quick Run

- Changed the config to only train for **10 epochs** for tonight — enough to see early results.
- You'll later increase epochs for better results once you're rested and back.

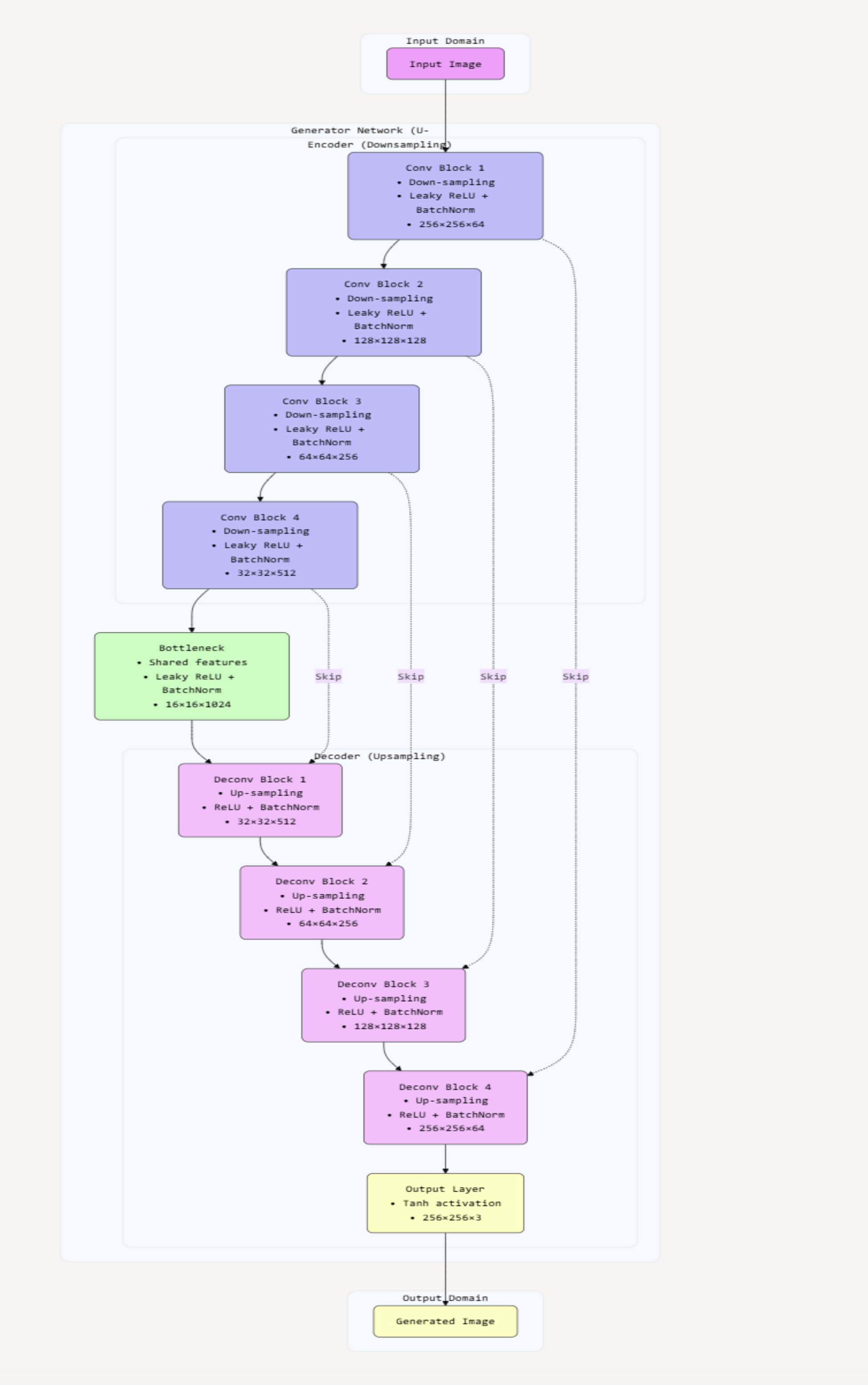
6. Cleared GPU Memory Before Restart
Used torch.cuda.empty_cache() and gc.collect() to clear GPU memory before restarting the session to avoid any out-of-memory issues or stale sessions

3.2 Proposed Work Architecture

1.CycleGAN architecture



2.Pix2pix architecture



3.3 Dataset Exploration

Dataset:

Figure 2. Photo dataset

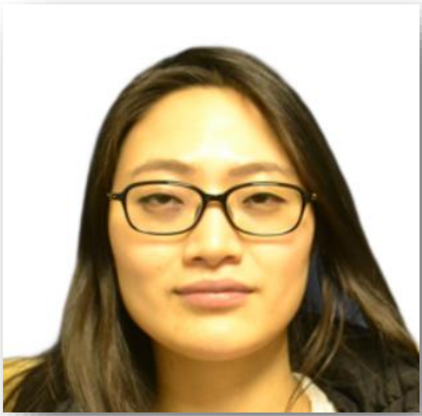


Figure 3. Photo dataset

3.4 Modules of the Proposed Work

1. Data Collection and Preprocessing

- Collect real-world images and cartoon-style reference images.
- Normalize images and apply edge-preserving filters like bilateral filtering.
- Augment the dataset using techniques such as flipping, rotation, and contrast adjustment.

2. Feature Extraction

- Use Convolutional Neural Networks (CNNs) to extract high-level textures, colors, and structure from input images.
- Retain important visual features necessary for accurate cartoon transformation.

3. Model Design and Training

- Implement CycleGAN for unpaired image-to-image translation (photo ↔ cartoon).
- Initialize and train four networks:
  - G_A: Photo → Cartoon
  - G_B: Cartoon → Photo
  - D_A, D_B: Discriminators for each domain
- Use cycle consistency and identity losses to ensure realistic transformation.

4. Image Translation Module

- Apply the trained model to transform new input photos into cartoon-style images.
- Use Pix2Pix in comparison (optional, for paired datasets) to evaluate effectiveness.

5. Post-Processing

- Apply adaptive histogram equalization and minor enhancements to improve visual appeal and contrast of the cartoonized image.

6. Evaluation Module

- Measure performance using:
  - SSIM (Structural Similarity Index)
  - Perceptual Loss
  - User study for subjective evaluation
  - Inference time analysis for deployment readiness

7. Deployment (Future Scope)

- Integrate the model into a simple web or mobile application for real-time cartoonization.
- Ensure user-friendliness and scalability.

4. EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Experimental Setup and Configuration

COMPONENTS	CONFIGURATION
PLATFORM	GOOGLE COLAB
GPU	NVIDIA TESLA T4
CPU	DUAL-CORE INTEL XEON
RAM	13GB
STORAGE	MOUNTED GOOGLE DRIVE
PYTHON VERSION	3.X
TENSORFLOW VERSION	LATEST IN COLAB

Table 1. Experimental Setup and Configuration

4.2 Loss Graphs after training

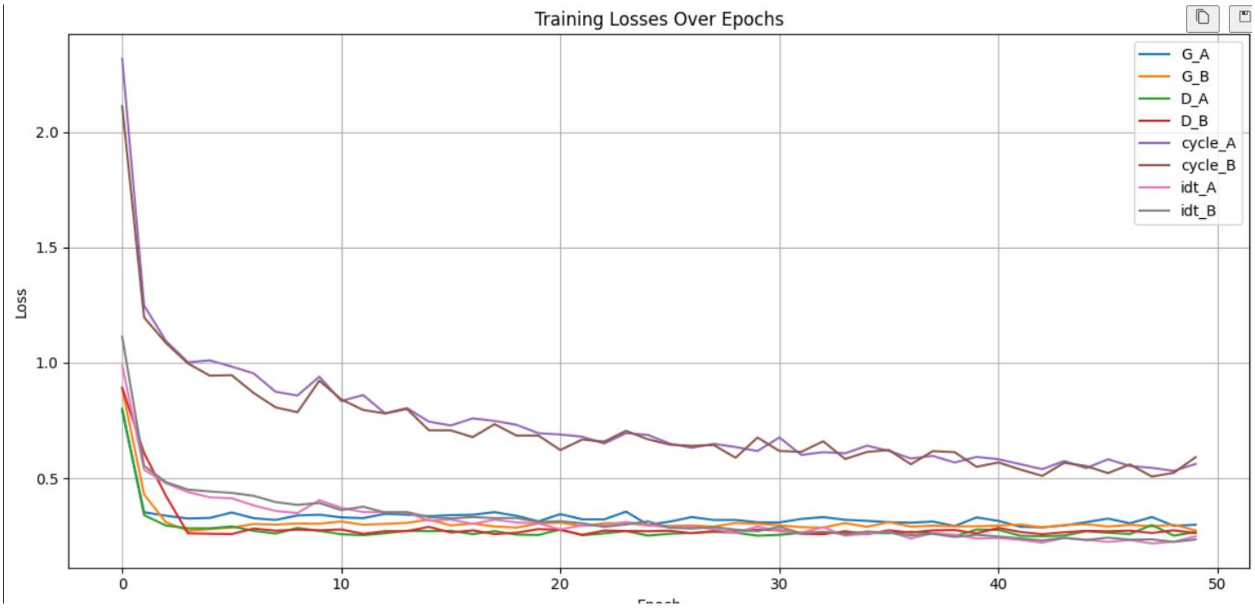


Figure 3. Training Losses Over Epochs

4.3. Final Output

Figure 4. Input image And Generated Image

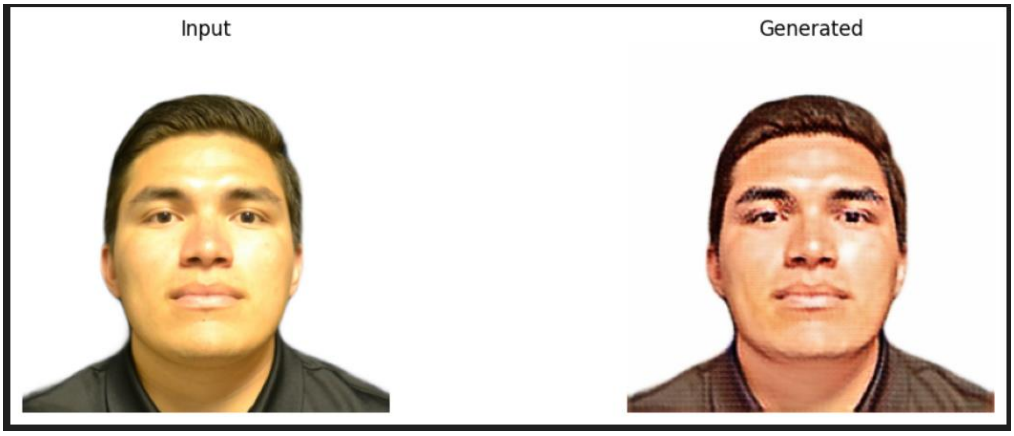


Figure 5. Input image And Generated Image

Figure 6. Input image And Generated Image

5. CONCLUSION

The experimental results demonstrate that the proposed deep learning-based cartoonization model effectively transforms real human images into cartoon-style outputs. As seen in the generated result, essential facial features are preserved while stylized textures and edges give the image a cartoon-like appearance. This is achieved using Generative Adversarial Networks (GANs), specifically CycleGAN, which successfully learns the mapping between real and cartoon domains without requiring paired datasets. The output image reflects key characteristics such as smooth shading, enhanced contours, and artistic detail, which are critical for cartoon aesthetics. This validates the capability of the model to generate visually appealing and semantically consistent cartoonized portraits. The outcome confirms that deep learning techniques, particularly GANs, are well-suited for creative image transformation tasks like cartoonization, with potential applications in entertainment, avatars, and social media filters.